Market Analysis of Alfalfa Hay: California Case

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Factors influencing alfalfa hay markets are identified. Alfalfa hay acreage response, demand, and price forecasting models are developed and estimated for California, using econometric and time-series (ARIMA) techniques. The estimated models are used for forecasting alfalfa acreage and prices, and evaluating the dominant market forces. The econometric and time-series models are compared on the basis of their forecasting ability and usefulness in economic analysis.

INTRODUCTION

Alfalfa is an important crop in the western states, both in terms of the acreage it occupies and as an input to the livestock industry. One-half of the US alfalfa acreage is located in the 17 western states, and in some of those states alfalfa accounts for more than a third of the cropland (Table I). Even though alfalfa is an important crop, only a few market studies have been conducted.

This article identifies major factors influencing alfalfa markets. Econometric acreage response, demand, and price forecasting models are specified and estimated. Each factor's affect on alfalfa acreage, price, and demand are assessed with the aid of these models. In addition, the estimated models are used to forecast alfalfa acreage and price. The acreage and price of alfalfa are also forecasted with time-series (ARIMA) techniques. The econometric and ARIMA formulations are compared on the basis of their forecasting ability and usefulness in market analysis.

There are two previous market studies on alfalfa; one by Blake and Clevenger (New Mexico)[1] and the other by Myer and Yanagida (11 western states.)[2] The purpose of both studies is to predict seasonal alfalfa prices. The authors link annual econometric price forecasting equations with quarter-

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Table I. Profile of Alfalfa Acreage in 17 Western States (1982).[a]

State	Alfalfa Area	Total Cropland Area	Share of Alfalfa
	(1000 acres)		(Percent)
Arizona	160	1174	14
California	960	9579	10
Colorado	710	9377	8
Idaho	1020	5624	18
Kansas	1000	28,352	4
Montana	1350	15,247	9
Nebraska	1600	20,816	8
Nevada	225	614	37
New Mexico	250	1690	15
North Dakota	1550	26,900	6
Oklahoma	370	10,935	3
Oregon	420	4324	10
South Dakota	2250	17,657	13
Texas	180	25,963	1
Utah	470	1409	33
Washington	460	7559	6
Wyoming	565	2264	25
Total	13,540	189,484	7
Percent US	52	50	

[a]Source: USDA Agricultural Statistics, 1985.[23]

ly/monthly price forecasting equations to predict quarterly/monthly alfalfa prices. The forecast results are generally satisfactory. However, neither study examines the determinants of alfalfa supply and demand in depth.

The present study focuses on the California alfalfa hay market. California ranks second in the nation, after Wisconsin, in alfalfa production. Within the state, alfalfa occupies 10% of the cropland and generates 7% of all income from crops.

Alfalfa is a free market crop with no restrictions on entry and exit from the market, no institutional price, and no production controls. The price of alfalfa is determined strictly by the free interplay of supply and demand.

In the next section determinants of alfalfa acreage response are discussed. Alfalfa farmers' acreage response behavior is modeled and estimated first econometrically and second using time series techniques. The two methods of modeling are compared on the basis of their forecasting ability and usefulness in economic analysis. In the third section a component demand model for alfalfa is formulated and estimated. In the fourth section, modeling and model comparisons similar to as in section two are conducted for alfalfa price behavior. The last section summarizes the results.

ACREAGE RESPONSE

The amount of acreage farmers devote to alfalfa is largely determined by its price, prices of competing crops, cost of production, rotation practices, and indirectly by government's acreage allotment and set-aside programs for cotton.

Crops that compete with alfalfa for land are primarily other field crops, such as barely, dry beans, corn, cotton, rice, sorghum, sugar beets, and wheat. To a lesser degree, tree crops, such as almonds, peaches, and grapes may also compete with alfalfa. However, such substitution usually occur in the long-run and do not determine the annual fluctuations of alfalfa acreage.

Costs of production play an important role as a supply shifter. Cost of irrigation water is the most prominent component in this category. The share of water cost in preharvest variable costs is 50% on average and rises to 80% in some areas of California (see Reed and Horel[3]). The cost of surface and ground water for irrigation has been increasing since the early 1970s, largely due to rising energy cost used in pumping water and to declining water table levels. The increase in the cost of water was largely responsible for the more than doubling of alfalfa production costs between 1970 and 1978 (see Yeary[4]). During this time, alfalfa acreage decreased by about 20% (see Fig. 1).

Alfalfa is rotated with other field crops for its beneficial side effects (nitrogen fixing). Some of the annual fluctuation of alfalfa acreage is due to such practices. However, there are no data on the extent and pattern of alfalfa rotation, therefore it will not be modeled. Another significant factor that affects alfalfa acreage is the government crop programs pertaining to cotton. Alfalfa competes with cotton for land in most crop regions of California. Cotton acreage allotment and set-aside programs were in effect between 1954 and 1972, which reduced the acreage planted with cotton. During the same period, alfalfa acreage increased substantially (see Fig. 1). The indirect impact of government programs on alfalfa acreage will be tested in this study.

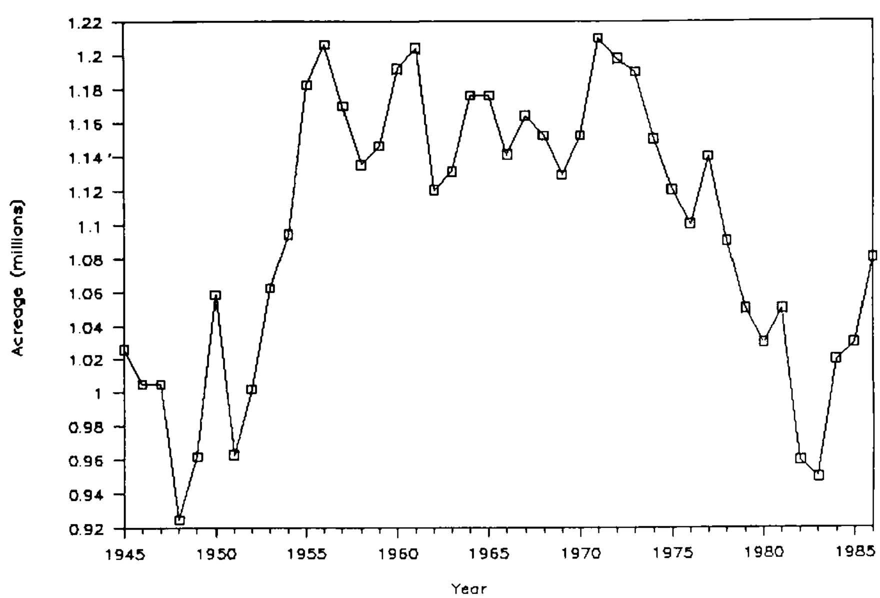

Figure 1. California Alfalfa Acreage.

Acreage Response Model: Econometric

Alfalfa is a perennial crop with an average stand life of between 3 to 7 years depending on climatic conditions and harvesting practices. In addition to Blake and Clevenger,[1] studies by Shumway[5] and Just[6] also estimate alfalfa acreage response functions. Neither of these studies explicitly consider the perennial nature of alfalfa. Studies that develop models for perennial crop supply response are Knapp;[7] French and Matthews;[8] Bateman;[9] Behrman;[10] Arak;[11] and Baritelle and Price.[12] The structural model developed here is similar to the model used by Knapp. Knapp's empirical analysis is normative while the current analysis is positive. In this study an equation for estimating alfalfa acreage response, based on a formal model of investment in perennial crops, is derived. This model explicitly incorporates the age distribution of the crop, investment in first-year plantings, and removal of acreage in each age category.

The acreage of alfalfa in year t is the sum of alfalfa acreage in different age groups,

$$A_t = \sum_{i=1}^{n} A_{it} \tag{1}$$

where A_{it} is acreage of alfalfa i years old in year t, and n is the maximum number of years alfalfa stays in the ground.

New plantings of alfalfa in year t, A_{1t}, is assumed to be a linear function of expected per acre profits from growing alfalfa, P_t^*, and expected per acre profits from growing competing crops, CP_t^*.

$$A_{1t} = b_0 + b_1 P_t^* + b_2 CP_t^* + u_t \tag{2}$$

where b_0, b_1, and b_2 are the coefficients and u_t is the error term.

A third equation,

$$A_{it} = A_{i-1,t-1} - R_{i-1,t-1} \qquad i = 2, \ldots, n \tag{3}$$

defines any alfalfa acreage older than one year, A_{it}, as the acreage in that age group in the previous year less the removals of that age group in the previous year. A set of equations in the following form,

$$R_{it} = r_{0i} + r_{1i} P_{t+1}^* + r_{2i} CP_{t+1}^* + e_{it} \qquad i = 1, \ldots, n-1 \tag{4}$$

postulates the removals of alfalfa in any group in year t, R_{it}, as a linear function of expected profits from alfalfa, P_{t+1}^* and competing crops, CP_{t+1}^* in the following year. The e_{it}'s are the error terms.

Based on Eqs. (1)–(4), the following acreage response equation is obtained.

$$A_t = \delta + \sum_{j=0}^{n-1} (\alpha_j P_{t-j}^* + \beta_j CP_{t-j}^*) + Z_t \tag{5}$$

where δ, α_j and β_j are the coefficients to be estimated and Z_t is the error term.* In the empirical analysis n is a parameter which will be estimated along with the other coefficients.

Farmers assume to exhibit a naive behavior in forming their expectation of P^* and CP^*, that is, they expect the current year's profits to prevail again in the following year. It is possible to specify other types of expectations, such as, Nerlovian type adaptive expectations, or rational expectations.+ The naive expectation assumption is a realistic one in view of persistent existence of the

See footnotes next page.

cobweb phenomenon in agricultural commodity markets. With the naive expectation assumption P_t^* and CP_t^* are replaced by P_{t-1} and CP_{t-1}

Time series data on production costs for alfalfa and competing crops are not available, therefore, the price of alfalfa and an index of competing crop prices, both divided by USDA's cost of crop production index, are used as a proxy for P and CP, respectively. The competing crop price index is constructed using California prices for barley, dry beans, corn for grain, cotton, rice, sorghum, sugar beets, and wheat. Each crop's price is weighted by its acreage, and the base year for the index is 1975. A dummy variable is also included to account for the cotton programs. All the data are obtained from California Crop and Livestock Reporting Service, Field Crop Statistics (1945–1982).

Equation (5), after substituting P_{t-1} and CP_{t-1} for P_t^* and CP_t^*, is estimated with a Generalized Least Squares routine. Estimation is repeated for different values for n, the maximum number of years a given alfalfa stand stays in production. The regression with the level of n that minimizes the sum of squared errors is chosen as the best regression estimate. This occurred with n=5. The actual practice of California alfalfa farmers confirm this result (see Flint et al.[13]).

The regression estimates are given in Table II under the column heading "Econometric I." Most of the estimated parameters are insignificant. The likely cause of insignificant estimates is multicollinearity among the explanatory variables. The multicollinearity was expected, since most variables are generated by lagging the two price series. The existence of multicollinearity results in insignificant, unstable, and, therefore, unreliable estimates. Yet, if the purpose is primarily forecasting, then multicollinearity may not be a serious problem. Good forecasts can be obtained despite the presence of multicollinearity (see Intriligator,[14] p.155). Therefore, the estimates are not used for economic analysis but are retained and used for forecasting acreage.

The model is re-estimated, substituting alfalfa acreage lagged one period, A_{t-1}, for the variables P_{t-2} through P_{t-5} and CP_{t-2} through CP_{t-5}. This approach is reasonable since A_{t-1} is a function of the excluded variables, and therefore, the information they provide is captured by lagged acreage and without posing the multicollinearity problem.

* The coefficients Eq. (5) are linear functions of the coefficients of Eq. (2) and (4) and are defined as,

$$\delta = nb_o - \sum_{i=1}^{n-1} r_{oi}$$

$$\alpha_j = b_1 - \sum_{i=1}^{n-j-1} r_{1i} \qquad j = 0, \ldots, n-1$$

$$\beta_j = b_2 - \sum_{i=1}^{n-j-1} r_{2i} \qquad j = 0, \ldots, n-1$$

$$Z_t = \sum_{j=0}^{n-1} u_{t-j} - \sum_{i=1}^{n-1} \sum_{j=1}^{n-i} e_{i,t-j}$$

COV $(Z_t, Z_{t-i}) \neq 0$ for $i = 1, \ldots, n-1$ and equals zero for $i > n-1$.

+ Equation (5) was also estimated with P^* and CP^* specified according to Nerlovian type adaptive expectation. The coefficient of adaption was estimated to equal 0.01, which indicates a naive price expectation behavior. The rational expectation hypothesis was not tested.

Table II. Econometric Estimates of Alfalfa Acreage Response in California.[a,b]

Variable Name	Econometric I Parameter Estimate	Econometric I Standard Error	Econometric II Parameter Estimate	Econometric II Standard Error
Intercept	1.18[c]	0.19	0.36[c]	0.15
P_{t-1}	0.21	0.15	0.24[c]	0.09
P_{t-2}	0.14	0.16		
P_{t-3}	−0.26[d]	0.15		
P_{t-4}	0.09	0.15		
P_{t-5}	−0.29[e]	0.14		
CP_{t-1}	8.53	8.95	−7.46[e]	3.29
CP_{t-2}	−22.54	11.52		
CP_{t-3}	7.75[d]	11.10		
CP_{t-4}	8.32	10.14		
CP_{t-5}	−5.27	7.16		
Dummy	0.09[c]		0.08[c]	
$Acre_{t-1}$			0.57[c]	0.12
F value	6.23		32.08	
R^2	0.77		0.80	
DW	1.45			
Durbin's h			0.87	

[a]Dummy = 1 for 1954–1972.
[b]Data are for 1945–1982.
[c]Significant at 1% level.
[e]Significant at 5% level.
[d]Significant at 10% level.

The result of the new regression is shown in Table II, under the column titled "Econometric II." All of the estimated coefficients have the expected signs and all are significant at the 1% level except CP_{t-1} which is significant at the 5% level. The model explains 80% of California alfalfa acreage variation.

The elasticity of supply with respect to own price and the price of competing crops are calculated from regression coefficients. Evaluated at the sample mean, the elasticities are 0.13 and −0.15, respectively. These magnitudes indicate that the response of California alfalfa acreage to price changes is small. This outcome is not surprising, because alfalfa is a perennial crop which makes it difficult for farmers to easily get in and out of the market. Also, a large percentage of alfalfa acreage in California is cultivated by dairy farmers to provide feed for their livestock. Such farmers are not expected to react very much to the year to year fluctuations of alfalfa price and competing crop prices, but rather they are expected to be concerned with having a reliable source of alfalfa supply.

The dummy variable captures the extent to which alfalfa acreage increases as cotton programs are implemented by the Federal government. During the 1954–1972 period when cotton acreage allotment and acreage set-aside programs were in effect, the average alfalfa acreage was 112,000 acres higher

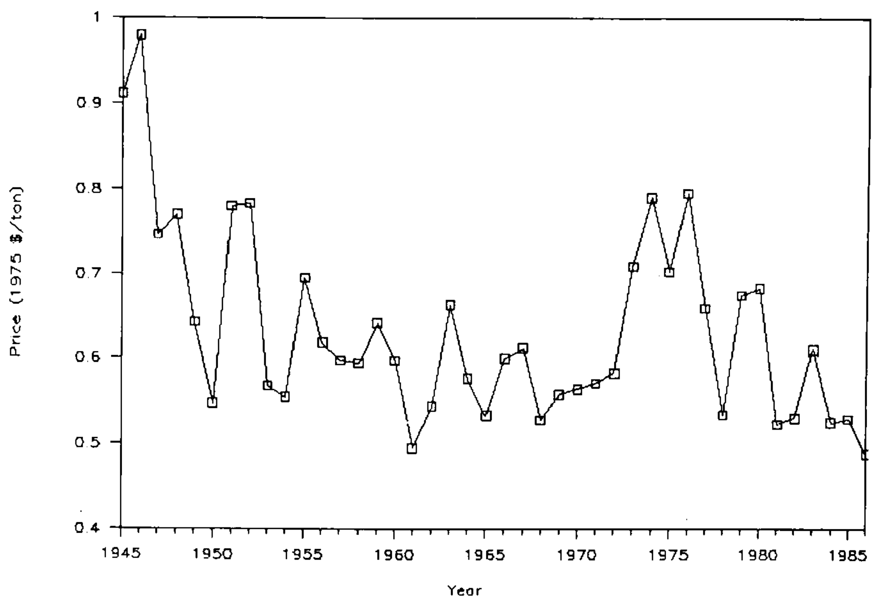

Figure 2. California Alfalfa Price.

than the average alfalfa acreage outside that period. The estimated coefficient of the dummy variable shows that about 80,000 of this increase in acreage is due to the cotton programs. If similar programs were to be put into effect again a similar increase in alfalfa acreage would be expected. The large increase in alfalfa acreage during the cotton programs forced alfalfa prices down (see Fig. 2). Measuring such indirect effects of government crop programs is important in assessing the impact of these programs on markets for non-program crops.

Acreage Response Model: Time Series (ARIMA)

A further purpose of this study is to forecast alfalfa acreage and prices. In many instances, ARIMA type time series models provide more accurate forecasts than the econometric models. To test this hypothesis, alfalfa acreage in California is modeled and forecasted using ARIMA techniques.*

The California alfalfa acreage series is differenced once to make the series stationary. Various ARIMA structures are tested. The model that minimize the

* The ARIMA model in general can be expressed as,

$$(1 - \phi_1 B - \phi_2 B^2 \cdots - \phi_p B^p)\,(1 - B^d)\,A_t = (1 - \theta_1 B - \theta_2 B^2 \cdots - \theta_q B^q)\,\varepsilon_t$$

where B is the backward shift operator, $(1-B)$ is the differencing, and d is the number of differencing. The term in the first left-hand side brackets is called the auto-regressive operator where p is its order and the ϕ_i's are the auto regressive parameters to be estimated. The term in the right-hand side brackets is called the moving average operator of order q and the θ_i's are the moving average parameters to be estimated. The term A_t is the value of the series at time t and ε_t is the white noise error term. The ARIMA model can be simply expressed as ARIMA (p,d,q).

Akaike Information Criterion (AIC) is chosen as the model best fitting the data. The best model is ARIMA (2,1,0) and the coefficient estimates are;

$$(1 + \underset{(0.167)}{0.065}B + \underset{(0.167)}{0.284}B^2)(1 - B)A_t = \varepsilon_t$$

with adjusted R^2 of 0.67. Figures in parentheses are the standard errors.

Acreage Forecast

The two econometric models and the ARIMA (2,1,0) model are used to forecast California alfalfa acreage for the 1983–1986 period. The actual values of the exogenous variables are used in the econometric forecasts. The results are given in Table III. Econometric II model gives the best forecast performance as evidenced by a lower mean absolute percentage error and a lower Theil's U_2 statistic compared to the errors from the other two models.* In addition, the Econometric II model predicts the direction of year-to-year changes in actual acreage accurately indicated by turning point error of zero.+ The other two models fail to capture the direction of change in some of the years, indicated by positive turning point errors. Also, the econometric II model has an added advantage over the ARIMA model, because it is based on a theoretical structure which allows the model estimates to be used for impact analysis. Although econometric models, in general, require more data than the ARIMA models, the data requirements of the current analysis are minimal and the data are readily available from published sources.

DEMAND

Quantity of alfalfa demanded is largely influenced by its price, prices of other livestock feed, the number of livestock that consume alfalfa, and the price of various livestock products.

Alfalfa is produced strictly for livestock consumption. In 1983, nearly 65% of California's alfalfa crop was fed to dairy cows, 18% was consumed by beef cattle, and 17% by horses and other livestock (Konyar[16]). Dairy cows in California rely heavily on alfalfa as their primary roughage intake and consume up to 30 pounds of alfalfa a day. Beef cattle consume small amounts of alfalfa per day compared to other types of feed, but their population in the aggregate has a sizeable impact on alfalfa demand.

*If forecasts are perfectly accurate then $U_2 = 0$. If predictions are made using the naive no-change extrapolation method, then U_2 will equal 1. Therefore, a forecast method whose predictions result in U_2 greater than 1 is no better than the naive method. The econometric II model is an improvement over the naive method because its U_2 is less than 1. The other two models fail to predict better than the naive model. See Theil (p.28)[15] for the calculation and interpretation of the U_2 statistic.

+The turning point errors occur when the forecast method fails to predict the direction of the actual change. The numbers reported in Tables III and V show the number of times the errors occurred. An error count of one-half reflects a prediction of change by the model when no change actually occurs, or a change occurring without the model predicting a change (see Theil, p.22).[15]

Table III. California Alfalfa Acreage Forecasts Results.

Year	Actual Acreage	Econometric I		Econometric II		ARIMA (2,1,0)	
		Forecast	Error%	Forecast	Error%	Forecast	Error%
	(1000)						
1983	950	1080	14	990	4	960	1
1984	1020	1080	6	1000	2	976	4
1985	1030	1160	13	1020	1	973	6
1986	1080	1090	1	1030	5	968	10
Mean Absolute Percentage Error			9		3		5
Theil's U_2			1.66		0.63		1.54
Turning Point			1.5		0		2

Horses also play a significant role in determining demand for alfalfa. The California horse population has gone up substantially in recent years, which has led to larger shares of alfalfa going to horses. Prices of other feeds, such as feed grains, corn, and oat silage also have a strong influence on per head alfalfa consumption by livestock. Furthermore, the price of livestock products also determines the demand for alfalfa, because alfalfa demand is primarily a derived demand by livestock.

Alfalfa Demand Model

Demand for alfalfa is modeled as component demand. The quantity of alfalfa demanded in California is postulated to equal alfalfa consumed by all cattle and by other livestock.

$$QD_t = QC_t \cdot CAT_t + QOTH_t \tag{6}$$

where,

$QD_t =$ quantity of alfalfa demanded in year t (1000 tons);

$QC_t =$ per head alfalfa consumption by beef and dairy cattle, year t;

$CAT_t =$ number of beef and dairy cattle in year t (1000 heads);

$QOTH_t =$ alfalfa consumption by all other livestock, year t.

The product term in Eq. (6) includes both beef and dairy cattle. Initially, these two livestock groups were kept separate, because per head consumption of alfalfa differs for each group. However, the regression results obtained from that formulation were very poor, because the dairy cattle numbers show very little variation during the sample period, and therefore, contain almost no information for regression estimation (see Fig. 3).

The following expression postulates a functional relation for QC_t.

$$QC_t = c_0 + c_2 PFEED_t + c_3 LPINDX_t \tag{7}$$

where P_t, $PFEED_t$, and $LPINDX_t$ are the price of alfalfa, price of other feed, and an index of livestock prices, respectively.

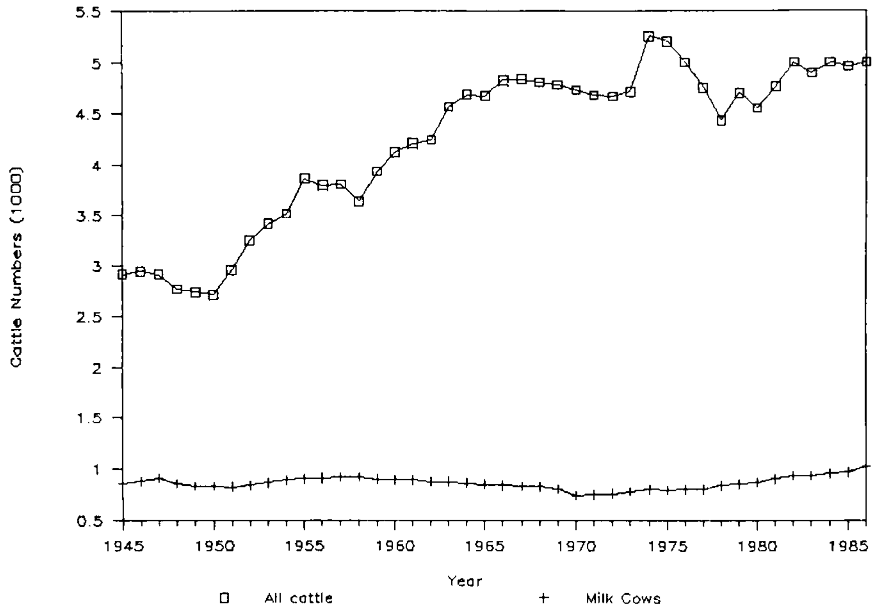

Figure 3. California Cattle Numbers.

The variable $QOTH_t$ consists almost entirely of alfalfa consumption by horses. As noted earlier, the number of horses in California has increased over the years. However, there are no time series data on horse numbers. Therefore, the consumption by horses is set to be a function of time alone, and expressed as,

$$QOTH_t = d_o + d_1 t \tag{8}$$

where t is a time trend. The following estimation equation is obtained by substituting Eqs. (7) and (8) into (6), and adding in the error term.

$$QD_t = d_o + (c_o + c_1 P_t + c_2\, PFEED_t + c_3\, LPINDX_t) \cdot CAT_t + d_1 t + e_t \tag{9}$$

Equation (9) is estimated using data from 1945–1982. Data sources are given in the references. Alfalfa consumption is calculated as alfalfa production plus May 1 carry-in stocks minus May 1 carry-out stocks. Alfalfa production consists of only California output and excludes the small amount of net imports into California, because there are no consistent data on California imports and exports of alfalfa. The variable *PFEED* is a weighted average index constructed using prices for corn, wheat, and oats. The variable *LPINDX* is an index consisting of a weighted average price of beef and milk.

The initial estimates of Eq. (9) gave poor regression results. The problem was the strong collinearity between the time trend and the cattle number series. The regression is re-estimated without the time trend and the results are shown in Table IV under the column titled "Demand." In the new regression the constant term accounts for the total quantity of alfalfa consumed by all livestock other than beef and dairy cattle.

The regression results are good as indicated by a high F value. With the exception of the last variable, all parameter estimates are significant at the 1%

Table IV. Econometric Estimates of Alfalfa Demand and Price Forecasting Models in California.[a]

Variable Name	Demand Parameter Estimate	Demand Standard Error	Price Forecasting Parameter Estimate	Price Forecasting Standard Error
Intercept	1644.910[b]	294.480	–11.948[c]	5.778
CAT_t	0.940[b]	0.084	0.007[b]	0.003
$TSUP_t$			–0.004[c]	0.002
P_t	–0.006[b]	0.002		
$PFEED_t$	0.002	0.001	0.393[b]	0.069
$LPINDX_t$	0.014[b]	0.006	1.673[b]	0.360
F value	70.37		208.09	
R^2	0.90		0.96	
DW	1.81		1.68	

[a]Data are for 1945–1982.
[b]Significant at 1% level.
[c]Significant at 5% level.

level. All coefficients have the expected signs. The variable cattle numbers, CAT, is the most statistically significant variable. The elasticity of demand with respect to cattle numbers is 0.78, evaluated at the sample mean. This estimate suggests a 7.8% increase in alfalfa consumption when cattle inventory increases by 10%.

Other elasticities of demand, evaluated at sample means, are –0.17 for the price of alfalfa, 0.16 for the price index of livestock products, and 0.11 for the price index of other feed. These magnitudes indicate an inelastic demand for alfalfa in California. This result was expected because, alfalfa is used in cattle rations, especially for dairy cows, in precise proportions in order to ensure proper protein, energy, and roughage intake. As relative prices change, there is little departure from the prescribed amount.

One valuable use of component demand regression is the information it provides regarding per head consumption of alfalfa by different categories of livestock. Such knowledge is critical for predicting the impact of changes in livestock inventory on alfalfa consumption. In many instances, data on per head consumption of alfalfa by different livestock categories is not available and it is cumbersome to obtain. However, the estimated coefficients of Eq. (9) can be used to calculate the different components of alfalfa consumption. For example, per head consumption of alfalfa by beef and dairy cattle can be obtained by computing the sum inside the parentheses in Eq. (9). Substitute the values for the variables inside the parentheses, multiply them with the estimated coefficients, and add. The consumption of alfalfa by cattle, calculated this way, using 1982 values for the variables, is 1.02 tons per year per head. This amount is remarkably similar to a 1982 normative estimate of 1.1 tons per year per head calculated by Konyar.[15] The approach taken here is straightforward. It involves estimating a regression equation, similar in form to Eq. (9) with readily available data.

The alfalfa consumption by all other livestock, mainly horses, is captured by the constant term of the regression and is estimated to be 1.64 million tons. The normative estimate of this category of alfalfa consumption is 1.74 million tons per year (Konyar[15], p.91). Once again the regression method provides a realistic estimate for the magnitude of a useful variable.

PRICE FORECASTING MODEL

Price Forecasting Model: Econometric

Factors influencing alfalfa price are modelled in the following linear form.

$$P_t = k_0 + k_1\, CAT_t + k_2\, TSUP_t + k_3\, PFEED_t + k_4\, LPINDX_t + u_t \tag{10}$$

The only variable not defined earlier is $TSUP_t$. This variable measures total alfalfa supply in California in year t, and it is defined as alfalfa produced in year t plus May 1 carry-in stocks from the previous year.

The regression results of Eq. (10) are given in Table IV under the column heading "Price Forecasting." All of the exogenous variables have the expected signs and statistically significant coefficients. The variables in the regression equation explain 96% of the variation in California alfalfa price. Alfalfa price flexibility, evaluated at the mean, is 0.71.

Price Forecasting Model: Time Series (ARIMA)

California alfalfa price movements are also modeled with an ARIMA (p,d,q) process. The series is differenced once to make it stationary. The ARIMA (2,1,1) model, which minimized the Akaike Information Criterion is chosen as the best model. It has the following coefficient estimates and an R^2 of 0.92.

$$\underset{(0.164)}{(1 + 0.643B} + \underset{(0.144)}{0.591B^2)}\,(1 - B)\,A_t = (1 + \underset{(0.144)}{0.794\mathrm{B}})\,\varepsilon_t$$

Price Forecast

The econometric price forecasting model and the ARIMA (2,1,1) model are compared on the basis of their forecasting ability. Results for a three year out-of-sample forecast are given in Table V. The ARIMA model performs slightly better than the econometric model when judged by mean absolute percentage error. However, the econometric model predicts better when judged using U_2 statistic. Both models anticipate the direction of annual alfalfa price changes correctly, as evidenced by turning point errors of zero.

A three period forecast test, however, is not sufficient to judge one model a better forecasting tool over the other. The estimated econometric model provides some very valuable information which is critical in explaining and predicting alfalfa price and consumption patterns. The time series model is based only on the past movements of price and useful only as a forecasting tool. A time series model may be preferable over an econometric model, if it forecasts endogenous variables more accurately and if forecasting is the sole purpose of the modeling effort.

Table V. California Alfalfa Price Forecast Results.

Year	Actual Price	Price Forecasting		ARIMA (2,1,1)	
		Forecast	Error %	Forecast	Error %
	($/ton)				
1983	97.1	89.8	8	94.5	3
1984	85.2	82.6	3	90.8	7
1985	83.2	75.0	10	90.4	9
Mean Absolute Percentage Error			7		6
Theil's U_2			0.72		0.76
Turning Point Errors			0		0

SUMMARY AND CONCLUSIONS

This study explored the dynamics of the alfalfa market in California. Alfalfa acreage response, demand, and price forecasting models were estimated to determine factors that are dominant in alfalfa markets. Alfalfa acreage response and demand were both shown to be inelastic with respect to its own and other relevant crop prices. Cattle inventory was shown to be the single most important determinant of alfalfa demand.

A set of time series models were estimated and compared to econometric acreage response and price models using forecasting accuracy and usefulness in market analysis as criteria. In most cases, the econometric models performed better than the time series models. It is difficult to judge which model will perform best in the long-run since the forecast tests were conducted with only a few years of data. The econometric models are based on theoretical structures and, therefore, they provide important insights into alfalfa market forces. Using the econometric estimates, an analyst can test the impact of exogenous variables on alfalfa acreage response, consumption, and price. Also, the econometric models of alfalfa acreage response and price can be used, in conjunction with a yield equation, to predict acreage and price into the future. Such a system will be self driving in that the predicted price from one period will determine the acreage in the next period, and so on. Different market scenarios can be imposed on this kind of combined model structure and multi-year impacts on acreage, price, and consumption can be predicted.

Econometric models usually require extensive data. Moreover, even when the data are available, analysts can not always successfully model the variables. The econometric models developed here are easy to use: they do not have excessive data needs and can be applied to other regions of the country where alfalfa is an important crop.

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